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GROWTH AND YIELD DATA for the IMPORTANT TIMBER SPECIES in NORTHERN NEW MEXICO

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(Studies)

GROWTH AND YIELD DATA

For the

IMPORTANT TIMBER SPECIES

in

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Foreword.

In 1908 the Santa Fe Railroad operating thru a subsidiary Company, the Santa Barbara Tie and Pole Company, commenced a lumbering operation on lands within the Rio Pueblo watershed, a tributary on the east side of the Rio Grande in Northern New Mexico, in lands belonging to the Santa Fe Railroad Company interests, known as the Santa Barbara Grant, for the purpose of supplying cross-ties to the Railroad. As cutting progressed, the logging front approached timbered lands on the north side of the Rio Pueblo belonging to the United States and administered by the Forest Service. Cutting commenced on Government lands in 1913 and has been carried on continuously to date.

With the exception of a few isolated stands, all of the timber lying within the Rio Pueblo watershed can be profitably logged at present for the purpose mentioned above. The bulk of the remaining virgin timber is owned by the United States, and it is planned to acquire the large alienated holdings within this working unit. Accordingly, in line with the Forest Service policy to apply a definite plan for handling all timbered areas under its jurisdiction, a plan of management providing for a sustained annual yield was deemed necessary for this watershed.

Since data regarding the rate of growth of the principal species within this area, the condition of the stand and the yield thereof, is necessary as a basis on which to build a plan of management, it was thought advisable to gather all of this material together in a document separate from the plan itself, which could be referred to as a text, and at the same time cutting down the bulk of the plan, thereby making that instrument more compact, hence more intelligible and usable for the administrative officer charged with the task of carrying out its prescriptions.

The first silvical investigations carried out on this area were done by C.F. Korstain in 1915. His data and conclusions are of record and included in a report entitled "Silvicultural Management of the Rio Pueblo and Rio Santa Barbara Watersheds, Santa Fe, National Forest". Supplemental work was done in all types on this same area during the summer of 1922. Accordingly, this report is being prepared to replace Korstain's work. Much of his work is included herein intact. Wherever more figures have been gathered, his data has been revised and added to.

The basic data given herein is applicable directly only to the Rio Pueblo watershed of the Carson National Forest, but nevertheless there is much valuable data representing an immense amount of work which can be used on other Forests having similar stands, thereby preventing duplication of much labor.

Much research work still remains to be done and as additional data is secured, it is planned to replace data given herein with the figures available.

Specifically, the area in question ranges in altitude from 7500 feet to timber line, 11,500 feet above sea level and therefore, sustains stands of all the saw-timber types common to the Southern Rocky Mountain Region, namely the yellow pine type, the Douglas Fir type and the Spruce type.

In the following pages, no attempt will be made to describe the silvics of the individual species. Stand conditions only, as affecting calculations necessary in building up a plan of management, will be dealt with.

Bd. Ft. and tie volume table for the principal species are also given inasmuch as such tables are necessary when arriving at the yield per unit of area after a given number of years succeeding the cutting of the virgin stand.

Reproduction.

Table 1. -- Comparative height growth of western yellow pine, Douglas Fir, White Fir, Engelmann Spruce and Cork Bark Fir seedlings.

Age Years	Height (Feet)				
	#Yellow Pine (Based on 124 seedlings). P.Ponderosa	#Douglas Fir (Based on 100 seedlings). Pseudotsuga Taxifolia.	#White Fir (Based on 100 seedlings) A. Concolor.	°Engelmann Spruce (Based on 128 seedlings.) P. Engelmanni.	°Cork Bark Fir (Based on 81 seedlings.) A.Arizonica.
6	.5			.81	.85
7	.6			.98	1.02
8	.7			1.14	1.18
9	.8			1.32	1.38
10	.9	.47	.30	1.51	1.59
11	1.0	.53	.35	1.71	1.78
12	1.2	.59	.40	1.90	2.01
13	1.3	.65	.45	2.12	2.23
14	1.5	.72	.50	2.34	2.51
15	1.7	.80	.56	2.57	2.75
16	1.8	.87	.63	2.82	3.08
17	2.1	.95	.70	3.07	3.37
18	2.4	1.0	.77	3.34	3.69
19	2.7	1.1	.85	3.58	3.98
20	3.0	1.2	1.0	3.89	4.31
21	3.5	1.3	1.1	4.17	4.66
22	4.0	1.5	1.2	4.74	4.92
23	4.7	1.6	1.3	4.82	5.24
24	5.5	1.8	1.4	5.06	5.56
25		1.9	1.5	5.45	5.90
26		2.1	1.7	5.87	6.22
27		2.3	1.8	6.30	6.57
29		2.6	2.0	6.71	6.91
30		2.8	2.2	6.99	7.26
31		3.2	2.5	7.32	7.54
32		3.6	2.8	7.64	7.97
33		4.4	3.2	8.06	8.33
34		4.8	3.4	8.44	8.14
35		5.3	3.8	8.67	9.21
36			4.2	9.25	9.60
37			4.6	9.47	10.20
			5.0	9.65	

Taken from Korstain's report.

° Compiled from field data obtained in the Angostura Spruce stand of the Rio Pueblo watershed during the summer of 1922.

No additional seedling analysis data for Pine, Douglas Fir, or White Fir was obtained since Korstain did his work. Accordingly, his figures are used without alteration. New data for Engelmann Spruce and Cork Bark Fir was gotten during the summer of 1922.

Method of Gathering Data :

Only seedlings growing in openings or not directly shaded, were selected. Each tree was cut off at the surface of the ground, and then split down the center, thereby exposing the pine knots. Each pine knot represents the termination of a year's growth. The distance from the bottom of the stem to every knot was measured, thereby giving the height growth for any year since germination of the seed.

CORK BARK FIR: (A. Arizonica)

Excellent data up to 36 years of age. The mathematical average for each year, when plotted, gives a smooth curve.

The field data gives same figures for height up to 64 years of age, but above 36 years the mathematical averages, when plotted, give a scattered appearance, indicating the lack of a sufficient number of trees. For that reason, data above 36 years has been disregarded.

ENGELMANN SPRUCE: (P. Engelmanni)

Excellent data up to 44 years of age. The field data gives some figures for height up to 64 years of age but, because of irregularities above 44 years, that data is disregarded.

The original field notes and calculations can be found in the Supervisor's files in Taos.

By comparing the data for Engelmann Spruce and Cork Bark Fir with that secured by Korstain for the same species in 1915, it is shown that the more recent data gives a much greater rate of height growth. This difference is accounted for by the fact that all of the seedlings analysed in 1922 were selected for normal growth. None were suppressed.

Apparently Korstain selected seedlings at random, thereby securing many suppressed plants.

Age Years	Engelmann Spruce: Korstain's 1915 data. Height in ft. Basis 53 trees	Engelmann Spruce: 1922 data Height in feet Basis 128 trees	Cork Bark Fir: 1915 data Height in feet Basis 50 trees	Cork Bark Fir: 1922 data Height in feet Basis 81 trees
10	.57	1.51	.45	1.59
15	.94	2.57	.75	2.75
20	1.40	3.89	1.10	4.31
25	2.00	5.45	1.60	5.90
30	2.80	7.32	2.30	7.54
35	4.00	9.25	3.30	9.60

The 1915 data shows the rate of growth of Engelmann spruce seedlings to be greater than that of cork bark fir seedlings. The 1922 data shows the two species to be growing at approximately the same rate, with the C. B. fir having a shade the better of the race for dominancy.

Because of the fact that the 1922 seedlings were carefully selected and a greater number were used as a basis, the 1922 table will be used in place of the original one. Furthermore, since the stand is now being opened up by cutting, reproduction, which survives, will naturally be that which is growing in the openings made by felling the older trees. The rate of height growth will then be greater than that for trees growing under the shade of the virgin stand and hence the 1922 table showing growth of seedling in the full sunlight will more closely approach the rate of growth of seedling when the forest is under management.

This table will be of value in determining the number of years required to reach stump height and breast height.

Another interesting sidelight gotten from an analysis of the above table is the information it gives concerning the early history of the present virgin spruce stand in the Angostura watershed.

Table No. 12, showing the average growth of Engelmann spruce for the different diameter classes, gives the height of a 4" tree as 31 feet.

Table No. 12, showing the age of the dominant Engelmann spruce trees in the present virgin stand for each d. b. h. class, gives the age of a 4" tree as 35 years.

According to Table No. 1, a 35 year old Engelmann spruce is only 9.2 feet tall.

These facts seem to indicate that the original stand, now mature (it is even aged also determined from stem analysis of 175

trees of various diameter classes) came in on an old burn, or else started after the destruction of the previous stand by some other agency, probably the spruce bud worm. There was then no light or root competition, except possibly from an aspen forest cover, and, accordingly, the original stand of seedlings grew much more rapidly than the present seedlings which are of the second generation and which are growing in competition with the established stand of parent trees.

Korstain's figures for Douglas Fir and White Fir show the height growth of seedlings to be very slow. In view of the results obtained in the Spruce stands, it is believed that another seedling study in the Douglas Fir type made from selected seedlings will show the 1915 figures to be low.

Table 2. -- Reproduction on average acre. Western Yellow Pine type. Based on 56, 1/40 acre plots -- By Korstain.

Class	Number of Seedlings and Saplings per Acre.					
	Western Yellow Pine	Douglas Fir	White Fir	Juniper	Pinon	All Species
1 feet seedlings	57.1	3.6	10.0	.70	---	71.4
2 " "	36.4	2.1	3.6	2.9	.7	45.7
3 " "	49.3	.7	1.4	.7	---	52.1
4 " "	27.1	2.1	2.1	--	---	31.3
5. " "	20.7	2.1	--	--	---	22.8
Total seedlings	190.6	10.6	17.1	4.3	.7	223.3
Saplings	85.7	1.4	3.6	6.4	---	97.1
Total Reproduction	276.3	12.0	20.7	10.7	.7	320.4
Per Cent	86.2	3.8	6.5	3.3	.2	100.00

Table No. 2 by Korstain, gives the advanced reproduction on an average acre within the yellow pine type. It has been determined by Pearson that 80 trees per acre within this type is a sufficient number to guarantee a cut throughout the second rotation period. It is safe to assume that the 97 saplings per acre are well enough established to be immune from droughts, and grazing animals.

By cutting the stand, many of the 223 seedlings will be released from moisture and light competition, hence the problem of securing reproduction in the Pine type is reduced to zero because of this adequate stand of young trees on the ground in the virgin forest.

Notwithstanding this fact, enough large seed trees must be left after cutting to provide sufficient seed to re-stock the area in case of fire and also to attempt to maintain a permanent crop of advanced reproduction to fill in openings made in the stand when the second cut of the first rotation period is made.

Table 3. -- Reproduction on average acre. Douglas Fir Type. Based on 29, 1/40 acre plots -- By Korstain.

Class	Number of Seedlings and Saplings per Acre			
	Douglas Fir	White Fir	Western Yellow Pine	All Species
1 feet seedlings	96.6	109.0		205.6
2 " "	37.2	85.5		122.7
3 " "	20.7	84.1		104.8
4 " "	16.6	59.3		75.9
5 " "	4.1	31.7	2.8	38.6
Total seedlings	175.2	369.6	2.8	547.6
Saplings	143.4	248.2	6.9	398.5
Total Reproduction	318.6	617.8	9.7	946.1
Per Cent	33.7	65.3	1.0	100.0

Table 3 by Korstain gives an estimate on a per acre basis of the average crop of advanced reproduction within the Douglas Fir Type. The density of stand within this type is greater than within the Pine Type. A glance at the table shows a total of 946 seedlings per acre. Three hundred ninety-eight (398) trees are classed as saplings, hence firmly established reproduction. This number in itself is sufficient to take up the space of the mature timber removed in the first cut.

About two-thirds of the total number of seedlings are White Fir. This majority is due to one of the silvicultural characteristics of that species, namely tolerance. However, the rate of height growth of Douglas Fir exceeds that of White Fir so that an opening in the stand naturally favors the former and more desirable species. The percentage of White Fir in the mature stand of the second rotation will most likely be no greater than it is in the present virgin stand. After management has been practiced for several cutting cycles, it will be possible to decrease the numbers of White Fir in the stand by eliminating all large White Fir seed trees and leaving only Douglas Fir to furnish seed for succeeding crops.

Table 4 -- Reproduction on average acre. Spruce Type. Based on 2.9 acres. Field data gotten during summer of 1922, in Angostura Watershed.

C. B. F.		Engelmann Spruce		Both Species	
Number of Trees	%	Number of	%	Number of	%
1391	88.7	178	11.3	1569	100.0

Table 4 gives the total number of seedlings and saplings under 3.6" D.B.H. only: Korstain gives a table in which the number of trees are separated according to height classes. His data was taken from 1/40 acre plots, whereas the above data was gotten by use of the strip method. The later compilation gives a smaller total number of small trees per acre and is thought to be more indicative of the actual conditions within the Spruce type in the watershed as a whole. Regardless of how nearly the actual average condition is indicated by either table, the fact remains that within the virgin stand there is more than sufficient reproduction to guarantee a second crop.

Cork Bark Fir seedlings greatly outnumber Engelmann Spruce, due to the less exacting seed bid requirements of the former species. Nevertheless, there is a considerable number of Engelmann Spruce seedlings on each acre. The latter species is the more hardy of the two associates and as the stand advances in age, it is the Cork Bark Fir that looses out in the race for supremacy. This condition is borne out by actual observation, i.e., the older the stand within the Spruce type, the greater the percentage by number of trees of Engelmann Spruce. In the stand under management, trees will not become over-mature. Therefore, in the second cut, there will be a considerable percentage of Cork Bark Fir.

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STAND:

Table 5. -- Stand on average cutover acre. Western Yellow Type. Based on 26 acres.

D.B.H. Outside Bark (Inches)	Average number of Trees per acre. Black Jack	Yellow Pine	Others	Total All Species	Number of Trees Curved
4	15.46	.08	.92	16.46	10.00
5	9.89		1.01	10.90	9.95
6	9.58		.18	9.76	9.70
7	6.65		.31	6.96	9.45
8	7.92	.12	.24	8.28	9.10
9	3.88			3.88	8.50
10	8.82	.31	.04	9.17	7.35
11	3.53	.16	.04	3.73	6.15
12	4.62	.35	.08	5.05	4.50
13	1.61			1.61	3.20
14	2.23	.09		2.32	2.50
15	.70	.04		.74	2.05
16	2.16	.15	.03	.34	1.65
17	.44	.08		.52	1.40
18	1.19	.19		1.38	1.15
19	.65	.03		.68	.85
20	.81	.08		.89	.40
21	.04			.04	.10
22	.42			.42	.10
23	.04			.04	.05
24	.08	.04		.12	
25	.08			.08	
26	.15		.05	.20	
27					
28			.03	.03	
29					
30					
31		.05		.05	
Total	80.95	1.77	2.93	85.65	88.15
Percent:	94.44	2.04	3.52	100.00	

The stand table for cutover areas in the Yellow Pine Type was compiled from data secured by the District Marking Board in 1914. In order to get a better average of number of trees by diameter classes, the averaged data was curved (see last column) and these values will be applied to the calculation for yield determination. It is desired to merely indicate the probable yield for a short period of years following cutting, therefore no allowance for mortality will be deducted for the reason that the trees in the large diameter classes are disregarded in the curved stand table. It is assumed that the volume of timber secured by cutting one or two large trees on every five acres, will more than take care of the mortality occuring in a short period of years among the smaller diameter classes.

Table 6. -- Stand on average cutover acre. Douglas Fir Type. Basis 308.8 acres. Agua Sarca caliper.

D.B.H. Outside Bark (Inches)	Average Number of Trees per Acre								Curved Stand
	D.Fir	W. F.	E.S.	Blue S.	C.B.F.	White Pine	Yellow Pine	All Species	
6	12.77	3.50	.54	1.24	2.42	.31	.08	20.86	21.00
7	6.43	1.91	.30	.72	1.21	.20	.03	10.80	16.30
8	9.64	2.35	.30	.86	1.17	.24	.05	14.61	12.65
9	6.52	1.47	.20	.54	.45	.17	.08	9.43	10.20
10	7.42	1.80	.15	.45	.48	.17	.09	10.56	7.50
11	5.10	1.12	.04	.20	.10	.06	.03	6.65	5.80
12	3.19	.75	.03	.16	.06	.10	.06	4.35	4.10
13	2.17	.41	.00	.09	.01	.05	.05	2.78	2.75
14	1.59	.36	.01	.04	.01	.03	.02	2.06	2.00
15	1.07	.27	.01	.03		.03	.02	1.43	1.45
16	.77	.29	.02	.03		.01	.05	1.17	.95
17	.29	.08	.01	.02		.01	.01	.42	.65
18	.49	.14		.03		.01	.05	.72	.50
19	.14	.05		.01			.01	.21	.45
20	.25	.09		.01		.01	.01	.37	.40
21	.10	.05					.01	.16	.25
22	.14	.04						.18	.15
23	.06	.01					.01	.08	.15
24	.08	.01		.01			.01	.11	.10
25	.03	.01					.01	.05	.05
26	.05	.01						.06	
27	.11	.01						.12	
28	.01	.01						.02	
29	.01	.01			.01			.03	
30	.01	.01						.02	
Total	58.44	14.76	1.61	4.44	5.92	1.40	.68	87.25	
Percent	66.99	16.92	1.81	5.13	6.79	1.61	.75	100.00	

The data for the Douglas Fir stand table (cutover stand) was secured by a 100% caliper of the entire Agua Sarca watershed, within the National Forest. The number of trees per acre was averaged by curving the values for each diameter class. This result appears in the last column and is the basis used for predicting yield on the average cutover acre. No allowance will be made for mortality for the first thirty years following cutting. Again it will be assumed that the volumn of the large trees left in the stand and disregarded in the curved table will offset mortality among the lower diameter classes.

Table 7 -- Stand on average cutover acre. Spruce Type. Basis strip survey 35.6 acres. Angostura watershed.

D.B.H. Outside Bark (Inches)	Average Number of Trees per Acre								
	Engelmann Spruce			Cork Bark Fir			Both Species		
	Normal	Suppressed	Total	Normal	Suppressed	Total	Normal	Suppressed	Total
4	10.39	8.06	18.45	20.79	11.57	32.36	31.18	19.63	50.81
5	15.39	5.73	21.12	20.00	6.60	26.60	35.39	12.33	47.72
6	15.51	2.98	18.49	17.58	3.32	20.90	33.09	6.30	39.39
7	15.22	1.09	16.31	14.33	1.32	15.65	29.55	2.41	31.96
8	14.10	.39	14.49	12.78	.73	13.51	26.88	1.12	28.00
9	12.61	.42	13.04	12.39	.14	12.53	25.00	.56	25.56
10	11.91	.11	12.02	9.18	.08	9.26	21.09	.19	21.28
11	9.18	.06	9.24	7.46	.06	7.52	16.64	.12	16.76
12	7.13		7.13	1.29		1.29	8.42		8.42
13	4.97		4.97				4.97		4.97
14	.08		.08				.08		.08
15	.03		.03				.03		.03
18	.06		.06				.06		.06
Total	116.58	18.84	135.42	115.80	23.62	139.62	232.38	42.66	275.04
Percent	42.38	6.85	49.23	42.11	8.66	50.77	84.49	15.51	

The stand on the average cutover acre of the Spruce Type was determined by a strip survey running across the topography of the entire Angostura watershed. Trees were divided into two classes, normal and suppressed. In predicting yield, the suppressed trees will be disregarded. It is assumed that by so doing, a sufficient factor will have been deducted to cover mortality for a thirty year period. In all likelihood, the resulting estimate of yield will be conservative, but for the reason that better data on mortality percent is lacking, it is believed that this assumption is more accurate than a mere guess.

GROWTH:

Table 8 -- Comparative growth in height and diameter of Blackjack and Yellow Pine on basis of diameter breast high.

(Based on 123 Blackjacks and 36 Yellow Pines)
Table by -- Korstain.

D.B.H. Outside Bark (Inches)	Height (feet)		Age (Years)	
	Blackjack	Yellow Pine	Blackjack	Yellow Pine
4	26	26	35	45
5	31	31	40	51
6	36	36	46	57
7	40	40	52	63
8	43.5	43.5	58	70
9	47	47	65	78
10	49.5	49.5	73	86
11	52	52	82	96
12	55	55	94	107
13	57	57	107	120
14	59	59	120	135
15	61.5	61.5	134	150
16	64	63.5	149	167
17	66	65.5	164	184
18	68	67.5	179	199
19	70.5	70	195	215
20	72.5	72	210	230
21	75	74	225°	246
22	77.5	76	240°	261
23	80	78.5	255°	277
24	82	80.5	270°	292
25		82.5		307
26		84		322
27		86		338
28		88		353
29		89.5		369
30		91		384

°Values interpolated in curving.

Table 9 -- Comparative growth in height and diameter of Blackjack and Yellow Pine on basis of age. (Based on 123 Blackjacks and 36 Yellow Pines)
Table by -- Korstain.

Age (Years)	Height (Feet)		Diameter Breast High (Inches)	
	Blackjack	Yellow Pine	Blackjack	Yellow Pine
20	9.5	5	1.4	.7
30	20	12.5	3.0	1.8
40	30.5	20.5	4.9	3.1
50	38.5	30.5	6.7	4.9
60	43.5	37.5	8.3	6.5
70	49	43	9.7	7.9
80	51.5	47.5	10.8	9.3
90	54	50.5	11.7	10.4
100	56	53	12.5	11.4
110	57.5	55	13.3	12.2
120	59.5	57	14.0	13.0
130	61	58.5	14.7	13.7
140	62.5	60	15.4	14.3
150	64	61.5	16.1	15.0
160	65.5	62.5	16.8	15.6
170	66.5	64	17.4	16.2
180	68	65	18.1	16.8
190	69.5	66.5	18.7	17.4
200	71	68	19.4	18.1
210	72.5	69	20.0	18.7
220	74.5	70.5	20.7	19.3
230	75.5	72	21.3	20.0
240	77.4	73.5	22.0	20.6
250	79	75	22.7	21.3
260		76		21.9
270		77.5		22.5
280		79		23.2
290		80		23.9
300		81.5		24.5
310		83		25.2
320		84		25.9
330		85		26.5
340		86		27.1
350		87		27.8
360		88.5		28.4
370		89.5		29.1
380		91		29.8

Table 10 --Comparative growth, in height and diameter of Douglas Fir and White Fir on basis of diameter breast high.
(Based on 86 Douglas Fir and 67 White Fir trees.) Table by -- Korstain.

D.B.H. Outside Bark (Inches)	Height (Feet)		Age (Years)	
	Douglas Fir	White Fir	Douglas Fir	White Fir
4	28	18	53	58
5	34	22	60	66
6	39.5	26	69	75
7	44	30	77	83
8	48	35	86	91
9	52	40	94	100
10	55	45	103	110
11	58	50	113	122
12	60	54	123	137
13	62.5	58	134	153
14	65	62	146	168
15	67	65	157	182
16	69	69	167	197
17	71	71	177	212
18	73	74	185	226
19	75	75	192	241
20	77.5	77	200	256
21	79.5		207	
22	81.5		215	
23	83		223	
24	85		232	
25	87		241	
26	88.5		250	
27	90		259	
28	91.5		268	
29	93		278	
30	94.5		288	

Table 11 --Comparative growth, in height and diameter, of Douglas Fir and White Fir on basis of age. (Based on 86 Douglas Fir and 67 White Fir trees) Table by - Korstain.

Age (Years)	Height (Feet)		D.B.H. (Inches)	
	Douglas Fir	White Fir	Douglas Fir	White Fir
30	3	2.5	.9	.6
40	16	8	2.3	1.7
50	25.5	13	3.6	2.9
60	33.5	18.5	4.9	4.2
70	40.5	24	6.2	5.6
80	45.5	30	7.3	6.9
90	50.5	35	8.5	8.0
100	54	41	9.6	9.1
110	57	45	10.7	10.0
120	59.5	49	11.7	10.9
130	62	52.5	12.7	11.6
140	63.5	55	13.5	12.3
150	65.5	57.5	14.4	12.8
160	67.5	60	15.3	13.5
170	69.5	62.5	16.3	14.2
180	72	65	17.4	14.8
190	75	67	18.7	15.5
200	77.5	69	20.0	16.2
210	80	71	21.3	16.9
220	82.5	73	22.6	17.6
230	85	74	23.8	18.2
240	86.5	75	24.9	18.9
250	88.5	76	26.0	19.6
260	90	77	27.1	20.3
270	92		28.2	
280	93.5		29.2	

Table 12 -- Comparative growth, in height and diameter of Engelmann Spruce and Cork Bark Fir on basis of D. B. H.

D.B.H. (Inches)	Height (Feet)				Age (Years)			
	Engelmann Spruce		Cork Bark Fir		Engelmann Spruce		Cork Bark Fir	
	xx 1915	1922 °	1915 ¢	1922#	xx 1915	x 1922	1915 ¢	1922
4	25	31	22.5	25	54	35	54	No
5	31	37	28	30	61	40	61	Field
6	37	44	33	35	66	45	66	Data
7	42.5	50	39	40	72	52	72	
8	48	55	44	44	78	60	78	
9	53	58	49	48	85	69	85	
10	58	61	54	52	93	78	93	
11	63	64	59.5	56	101	87	102	
12	67	66	65	No	109	96	112	
13	71.5	67	70	field	119	105	124	
14	75	69	75	data	129	115	136	
15	78	70	80	above	141	129	150	
16	81	71	86	11"	154	143	164	
17	84	72	87	DBH	169	158	178	
18	87.5	73	90		184		193	
19		74						
20		75						
21		76						
22		77						
23		78						
24		79						

xx Based on 61 trees
° Based on 439 trees
¢ Based on 32 trees
Based on 141 trees
x Based on 166 trees

Tables 8, 9, 10 and 11 are self-explanatory. No additional data for Pine, Douglas Fir or White Fir was obtained since Korstain completed his work. During the summer of 1922, some additional stem analysis data was obtained for Engelmann Spruce. Trees examined were all dominate growing in an even aged stand 135 years of age.

The discrepancy in the age column between Korstain's table and the 1922 table is due to the fact that Korstain based his height growth of seedlings on a study made largely on suppressed seedlings. Hence his time required to reach stump height is greater than the time to grow the same height used in the 1922 figures.

His greater height growth above 12 inches is due to difference in sites on which the trees studied were selected.

The ages given for the various diameter classes cannot be expected to be attained during the coming rotation, for the reason that the dominant trees in the virgin stand commenced growth without the necessity of competing with an overstory of mature timber. If it were possible to practice thinnings at 10 or 20 year intervals, it would most likely be feasible to produce a 14" tree in 115 years, but since present economic conditions preclude such a practice, it will be necessary to assume that a longer rotation (induced by decreased diameter growth due to competition) of 140 years is required to produce a 14" tree.

Table 13 -- Calculation to determine the size of the average tree cut in the virgin stand. Spruce type, Angostura Watershed.

D. B. H.	NUMBER of trees (Per Acre)	Basal Area Square Feet
10	9.67	5.26
11	10.67	7.04
12	14.66	11.51
13	13.66	12.59
14	9.83	10.51
15	7.01	8.60
16	4.66	6.50
17	3.17	4.99
18	2.50	4.42
19	1.17	2.30
20	.50	1.09
21	.67	1.61
22	.33	.87
23	.17	.49
Total	78.67	77.78

Diameter of average tree 13.5" D.B.H.

Marking in the virgin stand (Spruce type) is guided by a 14" diameter limit for Engelmann Spruce and 12" diameter limit for Cork Bark Fir.

The data given above was secured from a stump scale taken on the four permanent sample plots established in the Angostura watershed.

The virgin stand is about 135 years old, even aged, and has reached maturity. Thinnings could have profitably been made (from a silvicultural standpoint) for the stand is too crowded. The diameter of the average tree cut would then undoubtedly have been larger at the same age. However, a 14 or 15 inch tree is an ideal tie tree and it will be the object of management to produce such a tree.

Table 14 -- Actual averaged age of trees of various diameter classes. Young age class: Spruce stand: Angostura Watershed. Field data 1922. From stem analysis data.

D. B. H. (Inches)	ENGELMANN SPRUCE	
	Age (Years)	Number of Trees
10	128	1
11	148	3
12	133	12
13	127	16
14	130	32
15	131	36
16	133	21
17	135	16
18	139	11
19	141	6
20	145	9
21	142	4
22	151	4
23	159	4
Total		175
Net Aver.	134	

Table 14 is presented to show the actual age of the present virgin spruce stand in the Angostura watershed. The stand is even aged and approximately 135 years old. The size of the average tree cut is 13.5 inches D.B.H. These figures are of value in fixing the rotation age for the spruce type.

Determination of Rotation age for all types:

Since the stands within this watershed are to be managed on a tie rotation basis, the size of the optimum hewn tie tree will govern the diameter of the average tree to be produced. A 14" or 15" tree is the ideal tie tree, accordingly, it will be the aim of forest management to produce such a tree.

The preceding tables show the following comparison:

D. B. H.	Blackjack	Douglas Fir	Engelmann Spruce
14"	120	145	115

Undoubtedly, a different rotation age should be selected for each type. At present the data we have giving age on D. B.H. has been constructed from stump analysis. Trees selected for measurement were not picked for good crown development, but were

taken at random as found in the woods after a felling crew. Furthermore, a comparatively few trees were used in each determination. Therefore, for our present needs 140 years will be used as the rotation age for all types. It is pretty safe to assume that tie sized trees will be produced on all situations in that period of years.

A final determination of rotation age will be fixed in the future as results from the permanent sample plots now established become available. For our present needs, the length of the cutting cycle is the important factor to be considered in the management plan.

Table 15 -- Bark thickness of Engelmann Spruce at various heights.

D.B.H.	Bark Thickness at (Inches)								Number of trees
	Stump (1.3')	8'	16'	24'	32'	40'	48'	56'	
10	.25	.20	.20	.15					1
11	.25	.20	.20	.20	.15				3
12	.30	.25	.20	.20	.20	.20			12
13	.30	.25	.20	.20	.20	.20			16
14	.30	.25	.20	.20	.20	.20			32
15	.30	.25	.25	.20	.20	.20	.15		36
16	.35	.30	.25	.25	.20	.20	.20		21
17	.40	.30	.25	.25	.20	.20	.20		16
18	.40	.30	.30	.25	.25	.20	.20		11
19	.40	.30	.30	.25	.25	.25	.20	.20	6
20	.40	.30	.30	.25	.25	.25	.20	.20	9
21	.50	.35	.30	.30	.25	.25	.20	.20	4
22	.50	.35	.30	.30	.30	.25	.20	.20	4
23	.50	.40	.35	.30	.30	.25	.20	.20	4
									175

Table 16 -- The relationship between bark thickness at stump and breast high. Engelmann Spruce.

When the Double bark thickness at stump height (1.3') is: (Inches)	The double bark thickness at Breast height is:
.40	.40
.50	.45
.60	.50
.70	.55
.80	.60
.90	.65
1.00	.70
1.10	.70
1.20	.75

Based on 175 trees.

Table 17 -- Relation between diameter (inside bark) on stump and D.B.H. (outside bark) Engelmann Spruce. Angostura watershed.

Diameter Class	1 (Curved)		2 (Curved)		3
	Measured with rule on stump	Number of trees as basis	Measured with tape on standing tree	Number of trees as basis	Average of (1) and (2)
10	11.3	1	10.8	--	11.0
11	12.3	3	11.9	--	12.1
12	13.4	12	12.9	9	13.2
13	14.4	16	14.0	4	14.2
14	15.5	31	15.1	14	15.3
15	16.5	35	16.2	12	16.4
16	17.6	20	17.2	3	17.4
17	18.6	16	18.3	6	18.5
18	19.7	11	19.4	2	19.5
19	20.8	5	20.5	--	20.6
20	21.8	3	21.5	2	21.7
21	22.9	3	22.6	--	22.7
22	23.9	3	23.7	--	23.8
23	25.0	3	24.8	--	24.9
24	26.0	1	25.8	--	25.9

Note:

Under (1) diameters of stumps were measured with rule inside of bark. Under (2) diameters of stumps were measured on standing trees with diameter tape and outside of bark diameter inside of bark being obtained by subtracting bark thickness as obtained from stumps after these same trees were felled.

D.B.H. measurements were in each case taken with tape.

Table 18 -- Diameter inside bark and age at stump height (1.5') Engelmann Spruce. Dominant trees.

Age (Years)	Stump Diameter Inside bark (curved)	10 yr. Growth (Inches)	Basis No. of trees	Number of years required to grow one inch at stump height	
				Diameter (Inches)	Years
10	1.8	1.8	166	1-2	5
20	4.0	2.2	166	2-3	5
30	6.0	2.0	166	3-4	5
40	7.8	1.8	166	4-5	5
50	9.6	1.8	166	5-6	5
60	11.2	1.6	166	6-7	6
70	12.5	1.3	166	7-8	6
80	13.5	1.0	166	8-9	6
90	14.5	1.0	162	9-10	6
100	15.5	1.0	162	10-11	6
110	16.4	.9	158	11-12	7
120	17.0	.6	133	12-13	10
130	17.6	.6	64	13-14	10
140	18.1	.5	41	14-15	10
150	18.6	.5	14	15-16	11
160	18.8	.2		16-17	16
170	19.0	.2		17-18	20
180	19.2	.2		18-19	20

Tables 15, 16, 17 and 18 need no explanation

Table 19 -- Comparative diameter growth by decades of Engelmann Spruce and Cork Bark Fir, in cutover and in virgin stands. Spruce type Angostura watershed.

	Engelmann Spruce							
	Cutover Stand 1913 - 1922		Virgin Stand 1913 - 1922		Virgin Stand 1903 - 1912		Virgin Stand 1893 - 1902	
D.B.H.	Diameter Growth (Inches)	Trees	Diameter Growth (Inches)	Trees	Diameter Growth (Inches)	Trees	Diameter Growth (Inches)	Trees
4	.815	18	.322	17	.382	33	.409	33
5	.824	18	.330	24	.376	36	.506	36
6	.925	21	.458	18	.491	29	.555	29
7	.667	15	.530	18	.548	23	.648	23
8	.896	26	.468	17	.430	17	.520	17
9	.900	37	.488	23	.496	23	.652	23
10	.928	39	.452	22	.488	22	.600	22
11	.996	21	.454	19	.452	19	.502	19
12	.670	8	.628	26	.550	30	.648	30
13	.846	3	.614	26	.580	29	.679	29
14	.880	2	.614	22	.632	24	.707	24
Total		208		232		285		285
Wt.Av.	.876		.495		.489		.580	

	CORK BARK FIR							
	Cutover Stand 1913 -- 1922		Virgin Stand 1913 - 1922		Virgin Stand 1903 ~~00~~ 1912		Virgin Stand 1893 -- 1902	
D.B.H.	Diameter Growth (Inches)	Trees	Diameter Growth (Inches)	Trees	Diameter Growth (Inches)	Trees	Diameter Growth (Inches)	Trees
4	.580	6	.418	6	.418	12	.447	12
5	.814	6	.560	5	.456	11	.559	11
6	.956	4	.760	1	.896	5	.805	5
7	.921	10	.532	5	.653	9	.725	9
8	.830	6	.500	2	.790	2	.780	2
9	.940	3	--	-	--	-	--	-
10	.842	7	--	-	--	-	--	-
11	.830	4	--	-	--	-	--	-
12	1.280	3	--	-	.906	-3	.840	5
13	1.000	1	--	-	.800	1	.800	1
Total		50		19		43		43
Wt.Av.	.865		.512		.592		.626	

The field data from which Table 19 was compiled was secured in the spruce type by the use of the increment borer.

The data for the cutover areas was gotten in the Santa Barbara Grant in a stand cutover for ties in 1912. No borings were taken from suppressed trees; but only from intermediate, codominants and dominants. In other words, cores were extracted only from trees which have a good chance of surviving for the next thirty years.

In order to check the rate of growth of trees in cutover stands with trees growing in the virgin stand, a number of cores were taken from individuals having well developed crowns in a stand still in its original condition. Likewise, no suppressed trees were used in this investigation.

An analysis of the results shown in Table 18, brings out the point that the rate of diameter growth after release of the stand by cutting is approximately the same for each diameter class. It would be natural to suppose that trees in the smaller diameter classes would show a greater diameter increase in a given period than would those in the larger classes in the same period. Such is not the case in the stand studied. This discrepancy is due to the fact that trees in the 4" diameter classes are approximately the same age as those in the 14" class. The even aged condition of the stand is further brought out by the periodic diameter increased for trees in the virgin stand. Four and five inch Engelmann Spruce trees for the decade 1913-1922 show a growth of .322 and .330 inches respectively. Trees in the 14" class show an increase of .614 inches in diameter for the same period, indicating that 4" trees, even though not suppressed are less vigorous than their 14" brethern. However, when the stand is opened up all of the trees respond to added light and moisture conditions by increasing their diameter growth at about the same rate.

It is interesting to note that in the virgin stand, the averaged diameter growth is about the same for the last two decades, whereas, in the third decade, the rate of growth was greater. This difference is most likely due to one of two causes.

1. That the climate during the period 1893-1902 was more favorable to tree growth than during the past twenty years or:

2. That the stand reached maturity about 1902 and accordingly the rate of growth diminished.

In all likelihood, the second premise is the correct one in this case.

The important fact, from a management standpoint, is the great increase in diameter growth that actually occurs after the original

mature stand is cutover. For the reasons brought out above - that the stand is even aged, and that the rate of increase in growth is about the same for each diameter class - a weighted average figure for the periodic growth has been determined for all diameter classes. A comparison of this figure for the ten year growth of Engelmann Spruce in a cutover stand with the figure for an equal period of years in the virgin stand, shows an increase of 77%. For Cork Bark Fir, the rate of growth increase is 68.9% after cutting. With the data at hand, it is not possible to predict the duration of the acceleration after cutting. It isbelieved that during the second decade after cutting, in a stand comparable to the Spruce stands in Northern New Mexico, the per cent of acceleration will exceed that of the first decade, and thereafter will decrease as the stand becomes more crowded, due to increased growth, provided of course no thinnings are made.

For the purpose of predicting yield for a period of three decades after cutting, it is believed that the rate of acceleration for the first decade will be applicable for the entire period.

Table 20 -- Comparative diameter growth by decades of Douglas Fir in stands cutover in 1913. Data from increment cores.

D. B. H.	Cutover Stand 1913 - 1922		Virgin Stand 1903 -- 1912		Virgin Stand 1893 -- 1902	
	Diameter Growth (Inches)	No. of Trees	Diameter Growth (Inches)	No. of Trees	Diameter Growth (Inches)	No. of Trees
4	.840	12	.700	12	.680	12
5	.970	19	.714	19	.422	19
6	1.082	20	.864	20	.740	20
7	1.206	19	.916	19	.808	19
8	1.096	17	.796	17	.640	17
9	1.156	32	.856	32	.612	32
10	1.126	27	.742	27	.610	27
11	1.192	20	.746	20	.606	20
12	1.248	13	.882	13	.798	13
13	1.354	9	.982	9	.810	9
14	1.326	11	.910	11	1.018	11
15	.914	4	.686	4	1.094	4
16	1.282	7	1.066	7	.954	7
Total Trees		210		210		210
Weighted Average	1.137		.828		.692	

The field data for Table 20 was gotten by the use of an increment borer in a stand (Douglas Fir Type) cutover in 1913.

The stand is practically even aged and accordingly, the growth by decades is approximately equal in each diameter class.

The figures indicate that a decided increase in diameter growth occurs after cutting the virgin even aged stand. The increase over the average diameter growth for the two decades preceding cutting equals 49.6%. For Douglas Fir, the increased growth is not as great as it is in a released spruce stand where the increase amounts to 77% in the first decade after cutting. This difference is due to the different character of the stands. There are fewer trees per acre in the Douglas Fir type than in the spruce type. Accordingly, competition for light and moisture is keener in the latter stands, resulting in slower individual growth. A cutting operation in the spruce type results in a greater release of crowns of the remaining trees than in the Douglas Fir type where the release is due chiefly

to elimination of root competition. In other words, the remaining individuals in a spruce stand have a chance to develop better crowns and root systems after cutting, whereas, in a Douglas Fir stand, the crowns are hardly distrubed and the root systems only respond to an elimination of moisture competition.

Table 21 -- Comparative diameter growth by decades of Yellow Pine (Blackjack) in stands cutover in 1913. Data from increment cores.

D. B. H.	Cutover Stand 1913 - 1922		Virgin Stand 1903 - 1912		Virgin Stand 1893 - 1902	
	Diameter Growth (Inches)	No. of Trees	Diameter Growth (Inches)	No. of Trees	Diameter Growth (Inches)	No. of Trees.
4	1.134	12	.830	12	.622	10
5	1.072	16	.720	16	.716	14
6	1.114	16	.610	16	.746	16
7	1.338	11	.832	11	.816	11
8	1.214	14	.640	14	.678	14
9	1.090	12	.622	12	.584	12
10	1.064	12	.692	12	.882	12
11	1.292	14	.722	14	.744	13
12	1.434	15	.868	15	.818	15
13	1.142	14	.656	14	.684	14
14	1.268	11	.952	11	.936	11
15	1.222	12	.668	12	.540	11
16	1.060	10	.616	10	.726	10
17	1.272	11	.704	11	.890	11
18	1.196	11	.774	11	.914	11
19	1.240	11	.776	11	.616	11
20	1.772	7	1.114	7	1.202	7
Total No. of Trees		209		209		203
Weighted Average	1.216		.740		.763	

The accelerated growth, due to cutting in the yellow pine type amounts to 61.9%, i.e., greater than in the D. Fir type but less than the increased diameter growth in the Spruce type.

Again the periodic growth is approximately the same for each diameter class. In this case, the similarity cannot be explained by the fact that the stand is even aged for, obviously, various groups of blackjacks are of different ages. The increased rate of growth must be due to a stimulus induced by a greater supply of soil moisture resulting from a removal of the mature trees. Apparently, all blackjacks respond to increased water supply at about the same rate expressed in diameter growth. The effect of the various ages on diameter growth may be further brought out after another decade has elapsed.

Table 22 - Taper table for Engelmann Spruce. Average tree. Angostura watershed. Diameters are inside bark.

Diameter Class	Stump	8'	16'	24'	32'	40'	48'	Basis No. of trees	Total Height Curved
10	11.4	8.7	8.2					1	61
11	12.4	9.6	9.0	8.1				3	64
12	13.5	10.5	9.8	8.8	7.6			12	66
13	14.5	11.4	10.5	9.6	8.4			16	67
14	15.6	12.3	11.3	10.2	9.0			31	69
15	16.6	13.2	12.0	10.8	9.5	7.9		35	70
16	17.7	14.1	12.8	11.5	10.1	8.4		20	71
17	18.7	14.9	13.6	12.2	10.7	9.0		16	72
18	19.7	15.8	14.3	12.8	11.2	9.4	7.6	11	73
19	20.7	16.7	15.1	13.5	11.7	9.9	7.8	5	74
20	21.7	17.6	15.8	14.0	12.2	10.2	8.1	7	75
21	22.7	18.4	16.5	14.7	12.6	10.6	8.4	3	76
22	23.8	19.3	17.3	15.4	13.2	11.0	8.7	3	77
23	24.8	20.1	18.0	16.0	13.8	11.4	9.1	3	78
24	25.8	21.0	18.7	16.6	14.3	11.8	9.4	1	79
								167	

Table 23 -- Taper table for Engelmann Spruce 50' height class. Angostura Watershed.

Diameter Class	Stump	8'	16'	24'	32'	40'	48'	Basis No. of Trees
10	11.2	8.5	7.6					
11	12.2	9.3	8.3					
12	13.2	10.1	9.0	7.7				
13	14.2	10.9	9.6	8.2				
14	15.2	11.8	10.3	8.8				
15	16.3	12.6	11.0	9.3				Values
16	17.3	13.4	11.7	9.8	7.7			taken
17	18.3	14.2	12.3	10.3	7.9			Extension
18	19.3	15.1	13.0	10.8	8.2			of
19	20.3	15.9	13.8	11.3	8.5			Curves
20	21.3	16.7	14.4	11.9	8.8			
21	22.3	17.5	15.1	12.4	9.0			
22	23.4	18.4	15.8	12.9	9.3			
23	24.4	19.2	16.4	13.4	9.6			
24	25.4	20.0	17.1	14.0	9.9			

Table 24--Taper table for Engelmann Spruce 60' height class. Angostura Watershed.

Diameter Class	Stump	8'	16'	24'	32'	40'	48'	Basis No. of Trees
10	10.9	8.8	8.0					1
11	12.0	9.6	8.6	7.8				1
12	13.1	10.5	9.5	8.4				0
13	14.2	11.3	10.1	9.0	7.9			6
14	15.3	12.1	10.8	9.6	8.3			10
15	16.4	12.9	11.5	10.2	8.7			9
16	17.5	13.8	12.3	10.8	9.1			6
17	18.6	14.6	13.0	11.3	9.5			2
18	19.7	15.4	13.7	11.9	9.9	7.7		1
19	20.8	16.3	14.4	12.5	10.3	8.0		0
20	21.9	17.1	15.2	13.1	10.7	8.3		1
21	23.0	17.9	15.9	13.7	11.1	8.5		0
22	24.1	18.8	16.6	14.3	11.5	8.8		0
23	25.2	19.6	17.3	14.9	11.9	9.1		0
24	26.3	20.5	18.0	15.4	12.3	9.3		0
								37

Table 25 -- Taper table for Engelmann Spruce 70' height class. Angostura Watershed.

Diameter Class	Stump	8'	16'	24'	32'	40'	48'	Basis No. of Trees
10	11.2	8.8	8.3	7.7				0
11	12.3	9.7	9.0	8.4	7.6			2
12	13.4	10.6	9.8	9.0	8.1			7
13	14.5	11.4	10.6	9.6	8.6			10
14	15.5	12.3	11.3	10.3	9.1	7.7		18
15	16.6	13.2	12.1	10.9	9.6	8.0		23
16	17.7	14.1	12.8	11.6	10.1	8.4		7
17	18.7	14.9	13.6	12.2	10.6	8.8		9
18	19.8	15.8	14.4	12.8	11.1	9.1		8
19	20.9	16.7	15.1	13.4	11.6	9.5		4
20	21.9	17.6	15.9	14.0	12.1	9.9	7.8	4
21	23.0	18.4	16.6	14.7	12.6	10.3	8.0	2
22	24.1	19.3	17.4	15.3	13.2	10.6	8.2	1
23	25.2	20.2	18.2	16.0	13.8	11.0	8.4	1
24	26.2	21.0	18.9	16.6	14.2	11.4	8.6	0
								96

Table 26 - Taper tables for Engelmann Spruce 80' height class. Angostura Watershed.

D.B.H.	Stump	8'	16'	24'	32'	40'	48'	Basis No. of Trees.
10	11.0	8.8	8.3	7.8				0
11	12.1	9.8	9.2	8.5	7.8			0
12	13.3	10.7	10.0	9.2	8.3			2
13	14.4	11.6	10.9	10.0	9.0	7.8		0
14	15.5	12.6	11.7	10.7	9.5	8.3		3
15	16.6	13.5	12.5	11.4	10.1	8.8		3
16	17.7	14.4	13.4	12.1	10.7	9.3	7.6	7
17	18.8	15.4	14.2	12.8	11.3	9.8	7.9	5
18	20.0	16.3	15.1	13.5	11.9	10.3	8.2	2
19	21.1	17.2	15.9	14.3	12.4	10.8	8.5	1
20	22.2	18.2	16.8	15.0	13.0	11.3	8.8	3
21	23.3	19.1	17.6	15.7	13.6	11.9	9.0	1
22	24.5	20.1	18.4	16.4	14.2	12.4	9.3	2
23	25.6	21.0	19.3	17.2	14.8	12.9	9.6	2
24	26.7	22.0	20.2	17.9	15.3	13.4	9.8	1
								32

Tables 22, 23, 24, 25, and 26 were constructed from stem analysis data secured during the summer of 1922 in the Angostura watershed.

The data was compiled and put into the final form by use of the method described by Chapman in Chapter 15 of his "Forest Mensuration".

Table 22 giving the taper of the average tree has been used in compiling the volume tables to be used in predicting yield.

Tables 23, 24, 25, and 26, although based on but a few trees are thought to be of value for use in cruising timber within the Spruce type.

Such tables based on various height classes or on number of logs are badly needed and further field data to strengthen the above tables should be obtained as soon as possible.

Table 27 -- Tie and bd. ft. volume table for Engelmann Spruce. Average tree for each diameter class. Angostura stand.

D.B.H.	Hewn Ties				Sawed Ties			Vol. In Bd. ft. Scribner "C"	Actual Bd. Ft. contents of ties	% over or under run	Basis No. of trees
	6x6	6x8	7x8	7x9	6x8	7x8	7x9				
10	1							30	24	-20%	1
11	2							60	48	-20%	3
12	2	1						90	80	-11%	12
13	1	1	1					100	93	- 7%	16
14	2		1	1				120	127	+ 6%	31
15	1		1	1			1	150	145	- 3%	35
16	1		1				2	180	145	-19%	20
17	1	1		1	2			220	162	-26%	16
18	1		1		4		1	250	231	- 8%	11
19	1		1		2	2	1	290	242	-17%	5
20	1			1	2		3	330	256	-22%	7
21		1		1	5	2		350	309	-12%	3
22	1		1		6		3	380	380	- 0%	3
23	1		1		6		3	440	380	-14%	3
24	1			1	5	6		480	451	- 6%	1
											167

The last column in the table, showing % under or overrun, is based on the bd. ft. equivalent of the ties gotten from each log. No allowance has been made for side lumber since this product is not utilized on the operation to which these estimates are intended to apply.

Table 28 -- Tie and bd. ft. volume table for Engelmann Spruce. 50 ft. height class. Angostura Watershed.

D.B.H.	Hewn Ties				Sawed Ties			Vol. in bd. ft. Scribner "C"	Basis No. of Trees
	6x6	6x8	7x8	7x9	6x8	7x8	7x9		
10	1							20	
11	1							40	
12	2							60	
13	1		1					70	
14	1	1		1				90	
15	1		1	1				100	Values taken
16	1		1				1	130	
17		1		1			1	140	from extension
18			1		2		1	160	
19	1		1		2		1	180	of curves.
20	1			1	2	2		210	
21	1			1	2		2	220	
22	1				5		1	260	
23	1				3	2	1	280	
24	1				4		3	320	

Table 29 -- Tie and bd. ft. volume table for Engelmann Spruce. 60 ft. height class. Angostura watershed.

D.B.H.	Hewn Ties				Sawed Ties			Volume in bd. ft. Scribner "C"	Basis No. of Trees
	6x6	6x8	7x8	7x9	6x8	7x8	7x9		A
10	1							30	1
11	2							60	1
12	1	1						60	0
13	2		1					90	6
14	1		1	1				110	10
15	2		1				1	130	9
16	1		1	1			1	150	6
17	1		1		2		1	170	2
18	1			1	2		1	210	1
19		1		1	2	2		220	0
20		1			2		3	250	1
21	1		1		2		3	290	0
22	1		1		5	2		320	0
23	1			1	6		2	360	0
24	1			1		6	2	390	0
									37

Table 30 -- Tie and bd. ft. volume table for Engelmann Spruce 70 foot height class. Angostura watershed.

D.B.H.	Hewn Ties				Sawed Ties			Volume in Bd. Ft. Scribner "C"	Basis No. Of Trees
	6x6	6x8	7x8	7x9	6x8	7x8	7x9		
10	1							40	0
11	2							70	2
12	2	1						90	7
13	2	1	1					110	10
14	1	1	1	1				130	18
15	1		1	1			1	160	23
16	1		1				2	190	7
17	1	1		1	2		1	220	9
18	1		1		4		1	240	8
19	1		1		2	2	1	270	4
20	1			1	2		3	330	4
21		1		1	5	2		360	2
22		1			6		3	370	1
23			1		6		3	430	1
24	1		1		3	6	1	470	0
									96

Table 31 -- Tie and bd. ft. volume table for Engelmann Spruce. 80 foot height class. Angostura Watershed.

D.B.H.	Hewn Ties				Sawed Ties			Volume in bd.ft. Scribner "C"	Basis No. of Trees
	6x6	6x8	7x8	7x9	6x8	7x8	7x9		
10	1							40	0
11	3							70	0
12	2	1						90	2
13	2		2					130	0
14	1	1	1	1				150	3
15	2		1	1			1	170	3
16	1	1		1	2		1	210	7
17	1		1		2		2	250	5
18		1		1	2	2	1	280	2
19	1		1	1	4		2	310	1
20	1		1		2		5	370	3
21	1			1	5		3	430	1
22	1			1	7	2	1	450	2
23	1				6	4	3	510	2
24	1				6	4	3	570	1
									32

Table 32 -- Bd. Ft. volume table for Engelmann Spruce. Angostura Watershed.

D.B.H.	HEIGHT CLASSES				
	50'	60'	70'	80'	Average Tree
10	20	30	40	40	30
11	40	60	70	70	60
12	60	60	90	90	90
13	70	90	110	130	100
14	90	110	130	150	120
15	100	130	160	170	150
16	130	150	190	210	180
17	140	170	220	250	220
18	160	210	240	280	250
19	180	220	270	310	290
20	210	250	320	370	330
21	220	290	360	430	350
22	260	320	370	450	380
23	280	360	430	510	440
24	320	390	470	570	480

Tables 27, 28, 29, 30, 31 and 32 were constructed from the preceding taper tables and Scribner's decimal "C" rule for a log having a minimum top diameter of 7.6 inches for the bd. ft. contents. The tie grades were obtained from diagrams drawn for each half inch top diameter class.

Table 33 - Volume table, showing comparisons between principal species of each type.

D.B.H.	Blackjack °	Douglas Fir °	Engelmann Spruce
10	30	20	30
11	30	40	60
12	40	60	90
13	60	70	100
14	80	100	120
15	100	120	150
16	120	150	180
17	170	180	220
18	200	210	250
19	230	250	290
20	270	280	330
21	310	330	350
22	420	380	380
23	470	430	440
24	520	500	480
25		580	
26		670	
27		780	
28		890	
29		910	
30		1150	

° Korstain's table modified to read to nearest ten.

Table 34 - Yield per acre of Yellow Pine type.

D.B.H.	Average vol. per tie: Feet B.M.	Number of Ties: 7x9	7x8	6x8	Condition of Stand after first cut: No. of Trees°	Feet B. M.	Number of Ties: 7x9	7x8	6x8	Total Number Of Ties
4					10.00					
5					9.95					
6					9.70					
7					9.45					
8					9.10					
9					8.50					
10	30			1.2	7.35	220			8.82	
11	30			1.7	6.15	184			10.45	
12	40			2.0	4.50	180			9.00	
13	60		.8	2.2	3.20	192		2.56	7.04	
14	80		1.2	2.2	2.50	200		3.00	5.50	
15	100	.8	1.3	2.1	2.05	205	1.64	2.66	4.30	
16	120	1.6	1.2	1.8	1.65	198	2.64	1.98	2.37	
17	170	2.5	1.0	1.4	1.40	238	3.50	1.40	1.96	
18	200				1.15	230				
19	230				.85	215				
20	270				.40	108				
21	310				.10	31				
22	420				.10	42				
23	470				.05	23				
24	520				--	--				
Total						2266	7.78	11.60	50.04	69.42

° From Table 5.

Table 34-Continued. Condition of stand 10 years after first cut.

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Original D.B.H. (Inches)	Increase in Diameter in 10 years °	Diameter at end of 10 years	No. of Trees	Feet B. M.	Number of Ties 7x9	Number of Ties 7x8	Number of Ties 6x8	Total Number of Ties
4	1.2	5.2	10.00					
5	1.2	6.2	9.95					
6	1.2	7.2	9.70					
7	1.2	8.2	9.45					
8	1.2	9.2	9.10					
9	1.2	10.2	8.50	255			10.20	
10	1.2	11.2	7.35	210			12.49	
11	1.2	12.2	6.15	246			12.30	
12	1.2	13.2	4.50	270		3.60	9.90	
13	1.2	14.2	3.20	256		3.84	7.04	
14	1.2	15.2	2.50	250	2.00	3.25	5.25	
15	1.2	16.2	2.05	246	3.28	2.46	3.69	
16	1.2	17.2	1.65	280	4.12	1.65	2.31	
17	1.2	18.2	1.40	280				
18	1.2	19.2	1.15	264				
19	1.2	20.2	.85	229				
20	1.2	21.2	.40	124				
21	1.2	22.2	.10	42				
22	1.2	23.2	.10	47				
23	1.2	24.2	.05	26				
24	1.2							
Total				3025	9.40	14.80	63.18	87.38

° From Table 21

Table 34, Continued -- Condition of stand 20 years after first cut.

Original D.B.H. (Inches)	Increase in Diameter in 20 years	Diameter at end of 20 years	No. of Trees	Feet B. M.	Number of Ties			Total Number of trees
					7x9	7x8	6x8	
4	2.4	6.4	10.00					
5	2.4	7.4	9.95					
6	2.4	8.4	9.70					
7	2.4	9.4	9.45					
8	2.4	10.4	9.10	273			10.92	
9	2.4	11.4	8.50	255			14.45	
10	2.4	12.4	7.35	294			14.70	
11	2.4	13.4	6.15	369		4.92	13.53	
12	2.4	14.4	4.50	360		5.40	9.90	
13	2.4	15.4	3.20	320	2.56	4.16	6.72	
14	2.4	16.4	2.50	300	4.00	3.00	4.50	
15	2.4	17.4	2.05	348	3.07	2.05	2.87	
16	2.4	18.4	1.65	330				
17	2.4	19.4	1.40	322				
18	2.4	20.4	1.15	310				
19	2.4	21.4	.85	263				
20	2.4	22.4	.40	168				
21	2.4	23.4	.10	47				
22	2.4	24.4	.10	52				
23	2.4	25.4	.05	-				
Total				4011	9.63	19.53	77.59	106.75

Table 29 -- Tie and bd. ft. volume table for Engelmann Spruce. 60 ft. height class. Angostura watershed.

D.B.H.	Hewn Ties				Sawed Ties			Volume in bd. ft. Scribner "C"	Basis No. of Trees
	6x6	6x8	7x8	7x9	6x8	7x8	7x9		A
10	1							30	1
11	2							60	1
12	1	1						60	0
13	2		1					90	6
14	1		1	1				110	10
15	2		1				1	130	9
16	1		1	1			1	150	6
17	1		1		2		1	170	2
18	1			1	2		1	210	1
19		1		1	2	2		220	0
20		1			2		3	250	1
21	1		1		2		3	290	0
22	1		1		5	2		320	0
23	1			1	6		2	360	0
24	1			1		6	2	390	0
									37

Table 30 -- Tie and bd. ft. volume table for Engelmann Spruce 70 foot height class. Angostura watershed.

D.B.H.	Hewn Ties				Sawed Ties			Volume in Bd. Ft. Scribner "C"	Basis No. Of Trees
	6x6	6x8	7x8	7x9	6x8	7x8	7x9		
10	1							40	0
11	2							70	2
12	2	1						90	7
13	2	1	1					110	10
14	1	1	1	1				130	18
15	1		1	1			1	160	23
16	1		1				2	190	7
17	1	1		1	2		1	220	9
18	1		1		4		1	240	8
19	1		1		2	2	1	270	4
20	1			1	2		3	330	4
21		1		1	5	2		360	2
22		1			6		3	370	1
23			1		6		3	430	1
24	1		1		3	6	1	470	0
									96

Table 31 -- Tie and bd. ft. volume table for Engelmann Spruce. 80 foot height class. Angostura Watershed.

D.B.H.	Hewn Ties				Sawed Ties			Volume in bd.ft. Scribner "C"	Basis No. of Trees
	6x6	6x8	7x8	7x9	6x8	7x8	7x9		
10	1							40	0
11	3							70	0
12	2	1						90	2
13	2		2					130	0
14	1	1	1	1				150	3
15	2		1	1			1	170	3
16	1	1		1	2		1	210	7
17	1		1		2		2	250	5
18		1		1	2	2	1	280	2
19	1		1	1	4		2	310	1
20	1		1		2		5	370	3
21	1			1	5		3	430	1
22	1			1	7	2	1	450	2
23	1				6	4	3	510	2
24	1				6	4	3	570	1
									32

Table 32 -- Bd. Ft. volume table for Engelmann Spruce. Angostura Watershed.

D.B.H.	HEIGHT CLASSES				
	50'	60'	70'	80'	Average Tree
10	20	30	40	40	30
11	40	60	70	70	60
12	60	60	90	90	90
13	70	90	110	130	100
14	90	110	130	150	120
15	100	130	160	170	150
16	130	150	190	210	180
17	140	170	220	250	220
18	160	210	240	280	250
19	180	220	270	310	290
20	210	250	320	370	330
21	220	290	360	430	350
22	260	320	370	450	380
23	280	360	430	510	440
24	320	390	470	570	480

Tables 27, 28, 29, 30, 31 and 32 were constructed from the preceding taper tables and Scribner's decimal "C" rule for a log having a minimum top diameter of 7.6 inches for the bd. ft. contents. The tie grades were obtained from diagrams drawn for each half inch top diameter class.

Table 33 - Volume table, showing comparisons between principal species of each type.

D.B.H.	Blackjack °	Douglas Fir °	Engelmann Spruce
10	30	20	30
11	30	40	60
12	40	60	90
13	60	70	100
14	80	100	120
15	100	120	150
16	120	150	180
17	170	180	220
18	200	210	250
19	230	250	290
20	270	280	330
21	310	330	350
22	420	380	380
23	470	430	440
24	520	500	480
25		580	
26		670	
27		780	
28		890	
29		910	
30		1150	

° Korstain's table modified to read to nearest ten.

Table 34 - Yield per acre of Yellow Pine type.

D.B.H.	Average vol. per tie: Feet B.M.	Number of Ties: 7x9	7x8	6x8	Condition of Stand after first cut: No. of Trees°	Feet B. M.	Number of Ties: 7x9	7x8	6x8	Total Number Of Ties
4					10.00					
5					9.95					
6					9.70					
7					9.45					
8					9.10					
9					8.50					
10	30			1.2	7.35	220			8.82	
11	30			1.7	6.15	184			10.45	
12	40			2.0	4.50	180			9.00	
13	60		.8	2.2	3.20	192		2.56	7.04	
14	80		1.2	2.2	2.50	200		3.00	5.50	
15	100	.8	1.3	2.1	2.05	205	1.64	2.66	4.30	
16	120	1.6	1.2	1.8	1.65	198	2.64	1.98	2.37	
17	170	2.5	1.0	1.4	1.40	238	3.50	1.40	1.96	
18	200				1.15	230				
19	230				.85	215				
20	270				.40	108				
21	310				.10	31				
22	420				.10	42				
23	470				.05	23				
24	520				--	--				
Total						2266	7.78	11.60	50.04	69.42

° From Table 5.

Table 34-Continued. Condition of stand 10 years after first cut.

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Original D.B.H. (Inches)	Increase in Diameter in 10 years °	Diameter at end of 10 years	No. of Trees	Feet B. M.	Number of Ties 7x9	Number of Ties 7x8	Number of Ties 6x8	Total Number of Ties
4	1.2	5.2	10.00					
5	1.2	6.2	9.95					
6	1.2	7.2	9.70					
7	1.2	8.2	9.45					
8	1.2	9.2	9.10					
9	1.2	10.2	8.50	255			10.20	
10	1.2	11.2	7.35	210			12.49	
11	1.2	12.2	6.15	246			12.30	
12	1.2	13.2	4.50	270		3.60	9.90	
13	1.2	14.2	3.20	256		3.84	7.04	
14	1.2	15.2	2.50	250	2.00	3.25	5.25	
15	1.2	16.2	2.05	246	3.28	2.46	3.69	
16	1.2	17.2	1.65	280	4.12	1.65	2.31	
17	1.2	18.2	1.40	280				
18	1.2	19.2	1.15	264				
19	1.2	20.2	.85	229				
20	1.2	21.2	.40	124				
21	1.2	22.2	.10	42				
22	1.2	23.2	.10	47				
23	1.2	24.2	.05	26				
24	1.2							
Total				3025	9.40	14.80	63.18	87.38

° From Table 21

Table 34, Continued -- Condition of stand 20 years after first cut.

Original D.B.H. (Inches)	Increase in Diameter in 20 years	Diameter at end of 20 years	No. of Trees	Feet B. M.	Number of Ties			Total Number of trees
					7x9	7x8	6x8	
4	2.4	6.4	10.00					
5	2.4	7.4	9.95					
6	2.4	8.4	9.70					
7	2.4	9.4	9.45					
8	2.4	10.4	9.10	273			10.92	
9	2.4	11.4	8.50	255			14.45	
10	2.4	12.4	7.35	294			14.70	
11	2.4	13.4	6.15	369		4.92	13.53	
12	2.4	14.4	4.50	360		5.40	9.90	
13	2.4	15.4	3.20	320	2.56	4.16	6.72	
14	2.4	16.4	2.50	300	4.00	3.00	4.50	
15	2.4	17.4	2.05	348	3.07	2.05	2.87	
16	2.4	18.4	1.65	330				
17	2.4	19.4	1.40	322				
18	2.4	20.4	1.15	310				
19	2.4	21.4	.85	263				
20	2.4	22.4	.40	168				
21	2.4	23.4	.10	47				
22	2.4	24.4	.10	52				
23	2.4	25.4	.05	-				
Total				4011	9.63	19.53	77.59	106.75

Table 34, Continued -- Condition of stand 30 years after first cut.

Original D.B.H. (Inches)	Increase of Diameter in 30 years	Diameter at end of 30 years	No. of Trees	Feet B. M.	Number of Ties 7x9	Number of Ties 7x8	Number of Ties 6x8	Total Number of ties
4	3.5	7.5	10.00					
5	3.5	8.5	9.95					
6	3.5	9.5	9.70					
7	3.5	10.5	9.45	283			11.34	
8	3.5	11.5	9.10	273			15.47	
9	3.5	12.5	8.50	340			17.00	
10	3.5	13.5	7.55	441		5.88	16.17	
11	3.5	14.5	6.15	492		7.38	13.53	
12	3.5	15.5	4.50	450	3.60	5.85	9.45	
13	3.5	16.5	3.20	384	5.12	3.84	5.76	
14	3.5	17.5	2.50	425	6.25	2.50	3.50	
15	3.5	18.5	2.05	410				
16	3.5	19.5	1.65	379				
17	3.5	20.5	1.40	378				
18	3.5	21.5	1.15	356				
19	3.5	22.5	.85	357				
20	3.5	23.5	.40	188				
21	3.5	24.5	.10	52				
22	3.5	25.5	.10	--				
23	3.5	26.5	.05	--				
				5208	14.97	25.45	92.22	132.64

° The increase in diameter amounts to 3.6 inches. However, to be conservative 3.5 inches is used in order to prevent the addition of another diameter class to the predicted yield.

Table 34, Continued -- Condition of stand 30 years after first cut.

Original D.B.H. (Inches)	Increase of Diameter in 30 years	Diameter at end of 30 years	No. of Trees	Feet B. M.	Number of Ties 7x9	Number of Ties 7x8	Number of Ties 6x8	Total Number of ties
4	3.5	7.5	10.00					
5	3.5	8.5	9.95					
6	3.5	9.5	9.70					
7	3.5	10.5	9.45	283			11.34	
8	3.5	11.5	9.10	273			15.47	
9	3.5	12.5	8.50	340			17.00	
10	3.5	13.5	7.55	441		5.88	16.17	
11	3.5	14.5	6.15	492		7.38	13.53	
12	3.5	15.5	4.50	450	3.60	5.85	9.45	
13	3.5	16.5	3.20	384	5.12	3.84	5.76	
14	3.5	17.5	2.50	425	6.25	2.50	3.50	
15	3.5	18.5	2.05	410				
16	3.5	19.5	1.65	379				
17	3.5	20.5	1.40	378				
18	3.5	21.5	1.15	356				
19	3.5	22.5	.85	357				
20	3.5	23.5	.40	188				
21	3.5	24.5	.10	52				
22	3.5	25.5	.10	--				
23	3.5	26.5	.05	--				
				5208	14.97	25.45	92.22	132.64

° The increase in diameter amounts to 3.6 inches. However, to be conservative 3.5 inches is used in order to prevent the addition of another diameter class to the predicted yield.

Table 35 -- Yield per acre of Douglas Fir type. Condition of stand immediately after first cut.

D.B.H. (Inches)	Average Vol. per Tree				No. of Trees°	Feet B.M.	Number of Ties			Total No. of Ties
	Feet B. M.	Number of Ties 7x9	7x8	6x8			7x9	7x8	6x8	
4										
5										
6					21.00					
7					16.30					
8					12.65					
9					10.20					
10	20			.5	7.50	150			3.75	
11	40			1.5	5.80	232			8.70	
12	60			2.3	4.10	246			9.43	
13	70			2.7	2.75	192			7.42	
14	100		.8	2.7	2.00	200		1.60	5.40	
15	120	.3	1.2	2.4	1.45	174	.43	1.74	3.48	
16	150	.8	2.1	1.8	.95	142	.76	1.99	1.71	
17	180	1.4	2.3	1.2	.65	117	.91	1.49	.78	
18	210				.50	105				
19	250				.45	112				
20	280				.40	112				
21	330				.25	82				
22	380				.15	57				
23	430				.15	64				
24	500				.10	50				
						2035	2.10	6.82	40.67	49.59

° From Table 6.

Table 35, Continued -- Yield per acre of Douglas Fir Type. Condition of stand 10 years after first cut.

Original D.B.H. (Inches)	Increase in Diameter in 10 years	Diameter at end of 10 years	Number of Trees	Feet B.M.	Number of Ties 7x9	Number of Ties 7x8	Number of Ties 6x8	Total Number of Ties
4	1.1							
5	1.1							
6	1.1	7.1	21.00					
7	1.1	8.1	16.30					
8	1.1	9.1	12.65					
9	1.1	10.1	10.20	204			5.10	
10	1.1	11.1	7.50	300			11.25	
11	1.1	12.1	5.80	348			13.34	
12	1.1	13.1	4.10	287			11.07	
13	1.1	14.1	2.75	275		2.20	7.42	
14	1.1	15.1	2.00	240	.60	2.40	4.80	
15	1.1	16.1	1.45	217	1.16	3.04	2.61	
16	1.1	17.1	.95	171	1.33	2.18	1.14	
17	1.1	18.1	.65	136				
18	1.1	19.1	.50	125				
19	1.1	20.1	.45	126				
20	1.1	21.1	.40	132				
21	1.1	22.1	.25	95				
22	1.1	23.1	.15	64				
23	1.1	24.1	.15	75				
24	1.1	25.1	.10					
Total				2795	3.09	9.82	56.73	69.64

° From Table 20.

Table 35, Continued -- (Douglas Fir Type)
Condition of stand 20 years after cutting

Original D.B.H. (Inches)	Increase in Diameter in 20 years	Diameter at end of 20 years	Number of Trees	Feet B. M.	Number of Ties 7x9	Number of Ties 7x8	Number of Ties 6x8	Total Number of Ties
4								
5								
6	2.2	8.2	21.00					
7	2.2	9.2	16.30					
8	2.2	10.2	12.65	253			6.32	
9	2.2	11.2	10.20	408			15.30	
10	2.2	12.2	7.50	450			17.25	
11	2.2	13.2	5.80	406			15.66	
12	2.2	14.2	4.10	410		3.28	11.07	
13	2.2	15.2	2.75	330	.82	3.30	6.60	
14	2.2	16.2	2.00	300	1.60	4.20	3.60	
15	2.2	17.2	1.45	261	2.03	3.33	1.74	
16	2.2	18.2	.95	199				
17	2.2	19.2	.65	162				
18	2.2	20.2	.50	140				
19	2.2	21.2	.45	148				
20	2.2	22.2	.40	152				
21	2.2	23.2	.25	107				
22	2.2	24.2	.15	75				
23	2.2	25.2	.15					
24	2.2	26.2	.10					
				3801	4.45	14.11	77.54	96.10

Table 35, Continued -- (Douglas Fir Type)
Condition of stand 30 years after cutting

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Original D.B.H. (Inches)	Increase in Diameter in 30 years	Diameter at end of 30 years	Number of Trees	Feet B.M.	Number of Ties			Total Number of Ties
					7x9	7x8	6x8	
4	3.3							
5	3.3							
6	3.3	9.3	21.00					
7	3.3	10.3	16.30	326			8.15	
8	3.3	11.3	12.65	506			18.97	
9	3.3	12.3	10.20	612			23.46	
10	3.3	13.3	7.50	525			20.25	
11	3.3	14.3	5.80	580		4.64	15.66	
12	3.3	15.3	4.10	492	1.23	4.92	9.84	
13	3.3	16.3	2.75	412	2.20	5.77	4.95	
14	3.3	17.3	2.00	360	2.80	4.60	2.40	
15	3.3	18.3	1.45	304				
16	3.3	19.3	.95	237				
17	3.3	20.3	.65	182				
18	3.3	21.3	.50	165				
19	3.3	22.3	.45	171				
20	3.3	23.3	.40	172				
21	3.3	24.3	.25	125				
22	3.3	25.3	.15					
23	3.3	26.3	.15					
24	3.3	27.3	.10					
				5169	6.23	19.93	103.68	129.84

Table 36 - Yield per acre of Spruce type.
Condition of stand immediately after first cut.

D.B.H. (Inches)	Average Vol. per tree: Feet B. M.	Number of Ties: 7x9	7x8	6x8	6x6	No. of Trees: °	Feet B. M.	Number of Ties: 7x9	7x8	6x8	6x6	Total Number of Ties
4						31.18						
5						35.39						
6						33.09						
7						29.55						
8						26.88						
9						25.00						
10	30				1	21.09	632				21.09	
11	60				2	16.64	998				33.28	
12	90			1	2	8.42	758			8.42	16.84	
13	100		1	1	1	4.97	497		4.97	4.97	4.97	
14	120	1	1		2	.08	10	.08	.08		.16	
15	150	2	1		1	.03	5	.06	.03		.03	
16	180	2	1		1							
17	220	1		3	1							
18	250	1	1	4	1	.06	15	.06	.06	.24	.06	
19	290	1	3	2	1							
20	330	4		2	1							
21	350	1	2	6								
22	380	3	1	6	1							
23	440	3	1	6	1							
24	480	1	6	5	1							
							2915	.20	5.14	13.63	76.43	95.40

° From Table 7.

Table 36, continued -- Yield per acre of Spruce Type.
Condition of stand 10 years after first cut.

Original D.B.H.	Increase in Diameter in 10 years	Diameter at end of 10 years	No. of Trees	Feet B. M.	Number of Ties 7x9	7x8	6x8	6x6	Total Number of Ties
4	.9	4.9	31.18						
5	.9	5.9	35.39						
6	.9	6.9	33.09						
7	.9	7.9	29.55						
8	.9	8.9	26.88						
9	.9	9.9	25.00	750				25.00	
10	.9	10.9	21.09	1265				42.18	
11	.9	11.9	16.64	1497			16.64	33.28	
12	.9	12.9	8.42	842		8.42	8.42	8.42	
13	.9	13.9	4.97	596	4.97	4.97		9.94	
14	.9	14.9	.08	12	.16	.08		.08	
15	.9	15.9	.03	5	.06	.03		.03	
16	.9	16.9							
17	.9	17.9							
18	.9	18.9	.06	17	.06	.18	.12	.06	
19	.9								
20	.9								
21	.9								
22	.9								
23	.9								
24	.9								
				4985	5.25	13.68	25.18	118.99	163.10

732.38

° From Table 19.

Table 36 -- Continued.
Condition of stand 20 years after first cut.

Original D.B.H.	Increase in Diameter in 20 years	Diameter at end of 20 years	No. of Trees	Feet B. M.	Number of Ties 7x9	7x8	6x8	6x6	Total Number of Ties
4	1.8	5.8	31.18						
5	1.8	6.8	35.39						
6	1.8	7.8	33.09						
7	1.8	8.8	29.55						
8	1.8	9.8	26.88	806				26.88	
9	1.8	10.8	25.00	1500				50.00	
10	1.8	11.8	21.09	1898			21.09	42.18	
11	1.8	12.8	16.64	1664		16.64	16.64	16.64	
12	1.8	13.8	8.42	1010	8.42	8.42		16.84	
13	1.8	14.8	4.97	745	9.94	4.97		4.97	
14	1.8	15.8	.08	14	.16	.08		.08	
15	1.8	16.8	.03	7	.03		.09	.03	
16	1.8	17.8							
17									
18	1.8	19.8	.06	20	.24		.12	.06	
19									
20									
21									
22									
23									
24									
				7664	18.79	30.11	37.94	157.68	244.52

Table 36, Continued.

Condition of stand 30 years after first cut.

Original D.B.H.	Increase in Diameter in 30 years	Diameter at end of 30 years	No. of Trees	Feet B. M.	Number of Ties				Total Number of Ties
					7x9	7x8	6x8	6x6	
4	2.7	6.7	31.18						
5	2.7	7.7	35.39						
6	2.7	8.7	33.09						
7	2.7	9.7	29.55	886				29.55	
8	2.7	10.7	26.88	1613				53.76	
9	2.7	11.7	25.00	2250			25.00	50.00	
10	2.7	12.7	21.09	2109		21.09	21.09	21.09	
11	2.7	13.7	16.64	1997	16.64	16.64		33.28	
12	2.7	14.7	8.42	1263	16.84	8.42		8.42	
13	2.7	15.7	4.97	895	9.94	4.97		4.97	
14	2.7	16.7	.08	18	.08		.24	.08	
15	2.7	17.7	.03	7	.03	.03	.12	.03	
16									
17									
18	2.7	20.7	.06	21	.06	.12	.36		
19									
20									
21									
22									
23									
24									
				11059	43.59	51.27	46.81	201.18	342.85

Table 37 -- Comparative yields per acre of the different forest types within the Rio Pueblo watershed.

Ten Years after Cutting Virgin Stand.

	Pine Type		Douglas Fir Type		Spruce Type		
	Bd.Ft.	Ties	Bd.Ft.	Ties	Bd.Ft.	Ties °	Plus 6x6 Ties
10 yrs. after 1st cut	3025	87.38	2795	69.64	4985	44.11	163.10
Left after 1st cut	2266	69.42	2035	49.59	2915	18.97	95.40
Available to Cut	759	17.96	760	20.05	2070	25.14	67.70

Twenty Years after Cutting Virgin Stand.

	Pine Type		Douglas Fir Type		Spruce Type		
	Bd.Ft.	Ties	Bd.Ft.	Ties	Bd.Ft.	Ties °	Plus 6x6 Ties
20 yrs. after 1st cut	4011	106.75	3801	96.10	7664	86.84	244.52
Left after 1st cut	2266	69.42	2035	49.59	2915	18.97	95.40
Available to cut	1745	37.33	1766	46.51	4749	67.87	149.12

Thirty Years after Cutting Virgin Stand.

	Pine Type		Douglas Fir Type		Spruce Type		
	Bd.Ft.	Ties °	Bd.Ft.	Ties °	Bd.Ft.	Ties °	Plus 6x6 Ties
30 yrs. after 1st cut	5208	132.34	5169	129.84	11059	141.67	342.85
Left after 1st cut	2266	69.42	2035	49.59	2915	18.97	95.40
Available to cut	2942	63.22	3134	80.25	8144	122.70	247.45

° 6x6 Ties not included since not merchantable at present time. We have no taper tables for Pine and Douglas Fir, hence cannot arrive at the number of 6x6 ties for those species. Korstain's tie table used for Pine and Douglas Fir.

Tables 34, 35, 36 and 37 were compiled by using stand tables, increased growth by decades after cutting, and bd. ft. volume and tie tables. No allowance is made in these tables for mortality, that factor having been deducted in the stand tables, where the explanation is made.

Table 37 summarizes the yields of an average acre of the various types at different periods after cutting the virgin stand. It has been assumed that the quantity of merchantable timber left after the first cut is a good indicator of what should be on the ground after each cut, since the cutover stand is now in excellent condition generally. For that reason, the allowable cut has been arrived at by simply deducting the volume of the stand at the various periods after cutting.

CONCLUSION:

1. There is a sufficient amount of reproduction on the ground within all types, at the time of cutting the virgin stand to insure a full stocking of the area during the second rotation period. To insure the survival of this young stand, it will be necessary to exclude or control fires and to always leave enough large thrifty seed trees per acre (3 in Yellow Pine type, 1 in Douglas Fir type and 1 in Spruce type)° to insure an adequate seed supply.

° See District Marking Instructions.

2. There is a good distribution of diameter classes in the virgin stand of all types. By marking to a diameter limit of 14 inches for the most important trees in each type (Pine, Douglas Fir and Engelmann Spruce) and to 12 inches for the inferior associates, (White Fir, Limber Pine, Cork Bark Fir) enough trees will be left to insure a second cut in 30 years which will provide a volume equal to the original cut.

3. By cutting the original stand, the rate of growth of the remaining trees is greatly increased over the rate which they had been growing in diameter in the virgin stand.

For the first 10 year period after cutting, the rate of diameter growth for Douglas Fir increases 49.6%; Yellow Pine 61.9% and Engelmann Spruce 77%.

4. A rotation age of 140 years will produce an average tree for all species, of 14 or 15 inches (the optimum tie tree). The rotation age will have to be adjusted in the future as intensive management becomes feasible; (thinning will increase the average diameter of the trees in the same periods) growth plots will give much additional data in which the exact rotation age can be finally determined. It may be that a different rotation age will necessarily be adopted for each type.

5. A cutting cycle of thirty years will produce as much merchantable timber as was obtained when the virgin stand was cut. At that time, the marking rules may have to be changed in order to provide for a heavier cut under 14 inches D.B.H. of the principal species. After the second cut, as much timber will be left in the stand as remained after the first cut.

6. Additional stem analysis data is needed from which to construct taper tables for Douglas Fir, Yellow Pine, and to revise the Engelmann Spruce tables.

7. Stem analysis data for Douglas Fir and White Fir seedlings is needed in order to check Korstain's height growth tables (Table 1).

8. Thinning experiments should be inaugurated in the Spruce type in order to be prepared with such basis silvicultural knowledge when such information is needed, for it is predicted that a market for mine timbers or pulp wood will develop within twenty or thirty years which will make it possible to thin the stand.